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Moss and peat hydraulic properties are optimized to maximise peatland water use efficiency

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Peatland ecosystems are globally important carbon and terrestrial surface water stores that have formed over millennia. These ecosystems have likely optimised their ecohydrological function over the long-term development of their soil hydraulic properties. Through a theoretical ecosystem approach, applying hydrological modelling integrated with known ecological thresholds and concepts, the optimisation of peat hydraulic properties is examined to determine which of the following conditions peatland ecosystems target during this development: i) maximise carbon accumulation, ii) maximise water storage, or iii) balance carbon profit across hydrological disturbances. Saturated hydraulic conductivity (K_s) and empirical van Genuchten water retention parameter α are shown to provide a first order control on simulated water tensions. Across parameter space, peat profiles with hypothetical combinations of K_s and α show a strong binary tendency towards targeting either water or carbon storage. Actual hydraulic properties from five northern peatlands fall at the interface between these goals, balancing the competing demands of carbon accumulation and water storage. We argue that peat hydraulic properties are thus optimized to maximise water use efficiency and that this optimisation occurs over a centennial to millennial timescale as the peatland develops. This provides a new conceptual framework to characterise peat hydraulic properties across climate zones and between a range of different disturbances, and which can be used to provide benchmarks for peatland design and reclamation.